Examining the Influence of Business Models on Technical Implementation of Smart Services

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Abstract. This paper explores the relationship between business models and their technical implementation of smart services in the manufacturing industry. The study employed a research methodology that involved examining real-world use cases through expert interviews with companies offering smart services. The business models were assessed by using the business model patterns proposed by Gassmann et al. while the technical implementation aspect employed generic smart service patterns based on the conceptual model outlined in ISO/IEC 30141:2018. The data analysis resulted in the identification of 11 distinct generic smart service patterns with varying properties. Furthermore, the distribution of the business model patterns among the generic smart service patterns was examined to determine potential relationships and influences on the technical implementation of the smart service. This study's findings indicate several dependencies and connections between the technical implementation of smart services and their corresponding business models. The identification of interdependencies can serve as a foundation for informed decision-making in the planning and development phases of smart service implementation for organizations.

Keywords: smart services, digitalization, servitization, business model, IoT, IT architecture

1 Introduction

The manufacturing industry is undergoing a digital transformation, with companies increasingly leveraging technology to improve their operations and customer relationships [1]. Smart services, which involve communication and cloud technologies to gather information and data from a company's installed base, are one-way manufacturers achieve this. The data obtained through smart products can be used to offer new services, such as predictive maintenance and remote monitoring, and improve customer relationships through personalized service offerings and proactive customer engagement.

However, implementing and building smart service business models is not a simple task [2]. Many manufacturing companies lack the necessary resources and expertise to do so and must acquire or purchase new know-how and skills [3, 4]. Additionally, transitioning from product-centric to service-centric business models can be challenging, as for example, the selling process of services is different from selling products [5, 6]. Companies must also overcome technical and commercial challenges related to digitalization [7].

Despite the growing adoption of smart services in the manufacturing industry, there is a lack of understanding of the technical and strategic considerations involved in implementing these services. Previous studies have primarily focused on the business aspect of smart services [8–10], leaving a gap in knowledge on the technical implementation of digital services and the underlying business strategy decisions. This study addresses this gap and aims to answer the following questions: How does the business model impact the technical implementation of a smart service?

From expert interviews, specific case studies were extracted to illustrate how the technical implementation of digital services is influenced by various aspects of the organizations' business models. Based on this consideration, 11 distinct architectural patterns could be identified and set in context with their corresponding business models.

2 Literature review

2.1 Business models

Business models provide a structured and simplified representation of a company [11]. One of the most widely used approaches is the Business Model Canvas, developed by Osterwalder and Pigneur [12]. This framework includes nine building blocks describing a business model's key elements, customer segments, value proposition, channels, customer relationships, revenue streams, key resources, key activities, key partners, and cost structure [13].

Another approach for business models is provided by Gassmann et al. with their St. Galler Business Model Navigator. This toolkit includes a set of patterns that companies can use to create new business models. The patterns include examples of successful businesses and guide how to implement these business models. They describe business models based on four dimensions: Customer, Value Proposition, Value Chain, and Revenue Model [14].

2.2 Smart services and IoT

Digital servitization, the amalgamation of digitalization and servitization, presents novel opportunities for value creation and capture through smart product-service systems (SPSS) [15]. Pöppelbuß and Durst define smart services as a subset of SPSS [8] and as services that leverage data from smart products to deliver enhanced value to customers [16]. Similarly, Mittag et al. posit that smart services comprise a digital service that is based on data gleaned from a physical product, which may also be augmented by an additional physical service [8]. These smart services require a connection component in addition to their physical and smart components, as emphasized by Porter and Heppelmann [17]. The Internet of Things (IoT) offers a viable solution to this requirement by connecting the physical component of smart services to the Internet [3]. Ardolino et al. assert that IoT is crucial to digitalization as it enables the collection and transmission of data, making it a vital component of any service transformation strategy implementation [18].

2.3 Reference Architecture

Effective mapping of the technical structure of smart services requires a comprehensive reference architecture, and the ISO/IEC 30141:2018 standard provides such an architecture for IoT applications. This architecture consists of four essential aspects, including (1) the characteristics of IoT systems, (2) a Conceptual Model to represent the essential concepts and relationships of the elements of an IoT system, (3) a Reference Model to describe the overall structure of the architecture, (4) and a set of relevant views to represent the architecture from different perspectives [19, 20]

However, the IoT Architectural Reference Model (IoT ARM) is another model that provides concepts and definitions for IoT architectures, developed as part of the IoT-A project up to 2013. The IoT ARM defines four sub-models, including (1) the Domain Model, (2) the Information Model, (3) the Functional Model, and (4) the Communication Model, which together provide definitions of the key functionalities and communication paradigms for connecting elements in the IoT Domain Model and provide a guide for developing IoT-A compliant functional views and building interoperable stacks [21, 22].

3 Research methodology

The research methodology employed in this qualitative study is based on examining real-world use cases and is illustrated by Fig. 1. Given the technical complexity of smart services, a literature-based approach alone is insufficient to understand the subject matter comprehensively. Therefore, expert interviews with companies offering smart services were conducted to gain insight into these services' technical implementation and business models.

To be eligible for inclusion in the study, the use cases would have to meet the following criteria: (1) the smart service is offered to business customers, (2) the smart service consists of both a physical product and a digital service, and (3) IoT technology is used to connect the physical and digital components. A list of 32 potential use cases and corresponding contacts was compiled, and the companies were contacted. Of the 32 use cases initially identified, 9 were found not to meet the study's criteria, and no response was received from 4 companies. Expert interviews were conducted with the remaining 19 companies, focusing on a specific smart service offered by the company rather than the company's entire service portfolio.

The structured interviews aimed to gather information on the business model elements outlined by Gassmann et al., including the value proposition, value chain, revenue model, and target customers [14]. Following the interviews, the smart services were characterized by the business model (BM) patterns identified by Gassmann et al..

Additionally, the technical implementation of the smart services, discussed within the context of the value chain, was recorded using the conceptual model (CM) according to ISO/IEC 30141:2018.

The conceptual models were then standardized by uniformly naming entities, generalizing, combining elements, and limiting entities that occurred multiple times. The highest common denominator among the processed conceptual models was determined to be the base context module. Deviations from the base conceptual models were identified as generic smart service patterns or combinations of generic smart service patterns. These generic smart service patterns were then applied to the original conceptual models and sent back to the interviewees for feedback on their applicability. The feedback received was incorporated into the conceptual models, and the IoT patterns were adjusted as necessary. The result are 11 distinct generic smart service (GSS) patterns with varying properties. Finally, the co-occurrence of business model patterns and generic smart service patterns was examined to determine potential relationships and the impact of strategic business decisions on the technical implementation of the smart service.

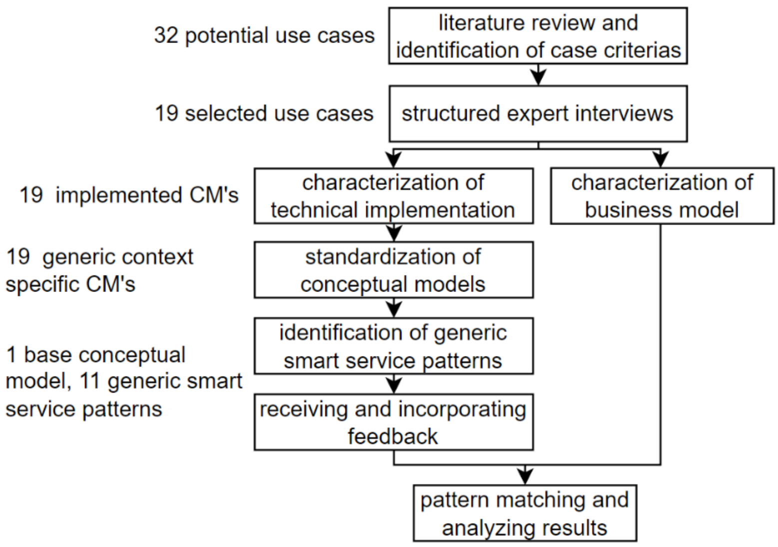

Fig. 1. Selected methodology for the qualitative study

4 Case Studies

The analysis of the relationship between the business model and the technical structure of Smart Service is based on the 19 case studies listed in Table 1. The table includes general information about the smart service provider, such as industry, the number of employees, and the age of the service. Furthermore, the GSS patterns, described in chapter 5, and BM patterns, according to Gassmann et al., are also listed. All companies studied in this research are headquartered in a country within the DACH region, the vast majority in Switzerland.

Table 1: Case Studies

#	Sector	Employees	GSS Patterns	BM Patterns	Age Service
1	Measuring and Control Instrument Manufacturing	250+	4,8	1,27,48,57	-
2	Construction	250+	3,6,11	7,11,25,34,40,48,56,57	1 year
3	Biotechnology Research	250+	3,8,9	18,57	6 years
4	Industrial Machinery Manufacturing	250+	2,6,8,11	1,25,32,48,57,58	3 years
5	Machinery Manufacturing	250+	4,5,8,9,11	19,25,27,47,48,57	2 years
6	Construction	250+	7	11,27,48,56,57	4 years
7	Machinery Manufacturing	50-249	2	11,34,57	3 years
8	Appliances, Electrical, and Electronics Manufacturing	250+	8,9,10,11	25,48,57	9 years
9	Appliances, Electrical, and Electronics Manufacturing	250+	9,10,11	7,11,25,40,48,56,57	7 years
10	Machinery Manufacturing	-	3,4,5,6,8	23,48,57	<1 year
11	IT Services and IT Consulting	1-9	3,4,5,6	11,23,48,57	6 years
12	Industrial Machinery Manufacturing	1-9	1,5,9	11,40,48,57	6 years
13	Wholesale	250+	1,2,3,9,10,11	11,25,31,48,40,57,58	+10 years
14	Transportation Equipment Manufacturing	250+	3,8,10,11	11,25,48,57	8 years
15	Utilities	10-49	3	11,48,56,57	2 years
16	Automation Machinery Manufacturing	50-249	3,5,8,9	23,48,57	2 years
17	Information Services	1-9	2,3	11,31,48,57	1 year
18	Industrial Machinery Manufacturing	1-9	3,4,5,11	11,23,48,56,57	2 years
19	Machinery Manufacturing	250+	8,9,10,11	20,25,39,47,57	+10 years

5 Generic smart service patterns

In this work, we present 11 generic smart service (GSS) patterns as technical counterparts to the business model (BM) patterns proposed by Gassmann et al. These patterns are described in accordance with ISO/IEC 30141:2018 and consist of various elements, which are detailed in chapter 5.1. Chapter 5.2 examines the fundamental architecture of every Smart Service, serving as the foundation for the GSS patterns outlined in chapter 5.3.

5.1 Entities

An entity describes an element of the CM according to the standard ISO/IEC 30141:2018. The entities of the base conceptual model (BCM) are described in more detail in Table 2. The description is based on the ISO/IEC 30141:2018 standard, the IoT-A standard, and experience from the use cases. The GSS patterns introduce additional entities. The entities can be classified into three distinct categories based on their operation and management. In Fig. 2, the entities that the smart service provider operates are shown with a hatch pattern. The dashed hatch pattern indicates that the smart service provider operates the entity in question. Finally, the crosshatch pattern indicates that a third-party organization operates the entity.

Table 2. Entities [20, 21].

Entity	Definition	Examples
Physical entity	A physical entity is a physical object, which can include living organisms and may have a hierarchical structure.	- Motor - Sheep - Machine
IoT device	IoT device connects physical and digital worlds with sensors and actuators to collect data and perform actions.	- Machine control - Sensor, Actuator
Local Network	A Local Network connects IoT devices to their gateway using protocols and relies on an IoT gateway for Internet access.	- CAN Bus - LoRa
IoT Gateway	An IoT gateway connects local devices to the Internet and provides various functions like protocol conversion, data processing, and security.	- LoRa gateway - Firewall
Internet	The Internet is a global access network that connects IoT devices and gateways with cloud applications.	
Service	A service is a digital entity, typically implemented as software on a server, and provided over the Internet.	- Backend - Analytics services
Data Storage	Data storage is persistently storing data in databases for various purposes, such as data analysis	- mySQL - InfluxDB
Application	An application is a digital software that executes tasks and interacts with users, hosted in the cloud and accessible through an interface.	- Dashboard - App - REST API
User	A user is someone or something that interacts with a smart service, including both human individuals and non-human automation services	- Customer - 3rd party service

5.2 Base conceptual model

The base conceptual model (BCM), shown in Fig. 2, was developed by identifying the commonalities among the 19 smart services that were studied. The BCM encompasses the fundamental capabilities of a smart service, including the ability to acquire data through IoT devices, transmit data through various networks, store data in a data storage by a service, and visualize data through an application. This model aligns with the foundational requirements of smart factory use cases, as described by Budde et al., which can also be applied to smart services [23]. In addition, the Smart Service Building Blocks appearing in every case study examined by Mittag et al. are also covered by the entities of the BCM [8].

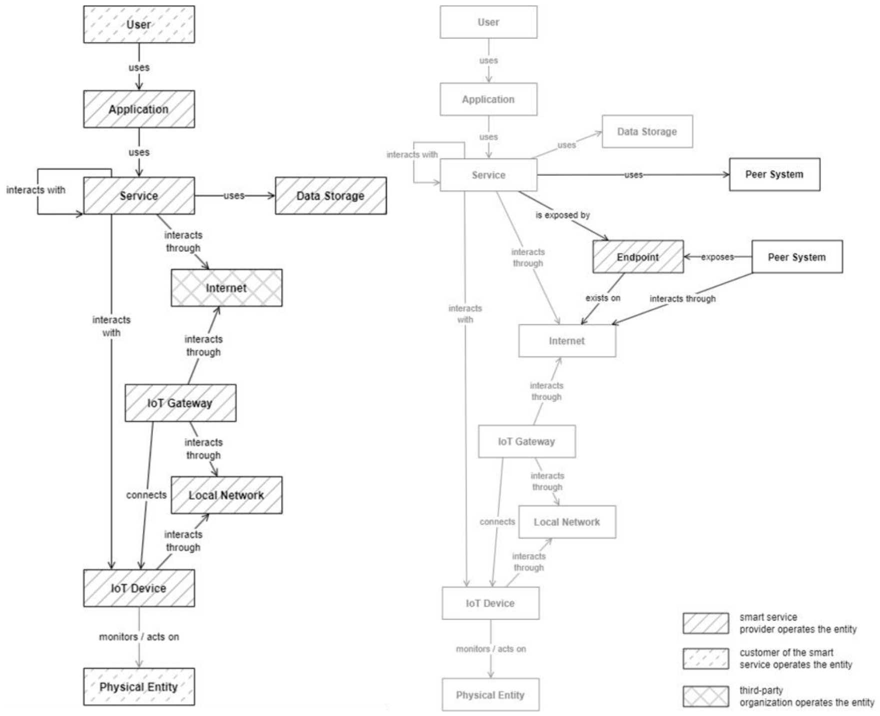

Fig. 2. Left: Base conceptual model, right: Conceptual model of pattern 5 *Enterprise Application Integration*, modelling language according to ISO/IEC 30141:2018

5.3 Generic smart service patterns

The analysis of the normalized use cases resulted in 11 generic smart service (GSS) patterns. These can be used independently or in combination with other generic smart service patterns. Table 3 shows the GSS patterns with the corresponding definition. As an example, Fig. 2 shows the conceptual model of GSS pattern *5 Enterprise Application Integration*.

Table 3. Generic smart service patterns

#	GSS Pattern	Definition
1	Physical Object is a Human	A human user is treated as a physical object, detecting input through sensors and providing feedback through actuators.
2	Partner for Connectivity	Outsourcing connectivity to partners for cost savings and scalability.

3	IoT Data Platform	The smart service offers a digital interface, typically an M2M interface, for querying data to integrate into existing 3rd parties systems.
4	Hybrid Data Storage	The telemetry data is stored in a special database, in addition to a database for the master data.
5	Enterprise Application Integration	The service queries and uses data from internal and external corporate services.
6	All-in-one	The IoT device also acts as an IoT gateway and typically communicates via the mobile network.
7	Smartphone as IoT Gateway	A customer's smartphone is used as an interface between an IoT device and the cloud.
8	Edge Gateway	Edge gateway is an IoT device that manages and gathers data from multiple IoT devices through a local network, optimizing communication with the cloud.
9	Customer Intranet	The IoT device is connected to the firewall through the customer's intranet, which serves as a gateway to the Internet.
10	User-Object Service	The smart service provider offers remote or physical services to a physical entity.
11	Data-Driven Insights	The smart service provider uses data from IoT devices and other sources to optimise products, services and internal processes.

6 Discussion

The contingency table analysis between GSS patterns and BM patterns in Fig. 3 reveals several dependencies and connections between the two. One notable example is the frequent co-occurrence of BM pattern 25, *Leverage Customer Data*, and the GSS pattern 11, *Data-Driven Insights*. The case studies demonstrate that in order for a company to use customer data for service optimization or product improvement effectively, a corresponding interface, such as dashboards or an M2M interface, must be made available to employees by the smart service, and employees must be authorized and trained to read and use the customer data. This disclosure, possibly also to third parties, must be contractually defined. These patterns occur in just under half of all the cases examined, suggesting that leveraging customer data is a key opportunity for companies to differentiate themselves from competitors. Similarly, Kowalkowski and Ulaga highlight the importance of companies collecting data from their installed bases and using it strategically [24].

Another trend observed is the increased co-occurrence of BM Pattern 11, *Digitalization*, and GSS Pattern 8, *IoT Data Platform*. This may be due to companies digitalising objects for their customers via sensors and making this data available to the customers via an interface such as REST API. Additionally, the value proposition of smart services often includes simplifying the customer's life through the virtualization of a physical process, such as reading a sensor or ordering spare parts. This is reflected in the high frequency of BM Pattern 57, *Virtualization*, in every single use case. BM Pattern 48, *Subscription*, also occurs frequently as companies with smart services aim to generate recurring revenue and therefore prefer to offer the services in a subscription model, as also pointed out by Bonnemeier et al. [9], Rabe et al. [8], and Wortmann et. al [25].

It is also noteworthy that every smart service, except for Case Study 14, incorporates either BM Pattern 11, *Digitalization*, or GSS Pattern 8, *Edge Gateway*. The implementation of BM Pattern 11 implies using an IoT device to measure influencing variables such as current or temperature. On the other hand, GSS Pattern 8, *Edge Gateway*, is employed in situations where a digitalised system, such as a machine control system, already exists. Both options require an IoT device to digitalise the physical world, yet in the case of an edge gateway, the IoT device is not included in the functional scope, resulting in the exclusion of BM Pattern 11, *Digitalization*, from the smart service.

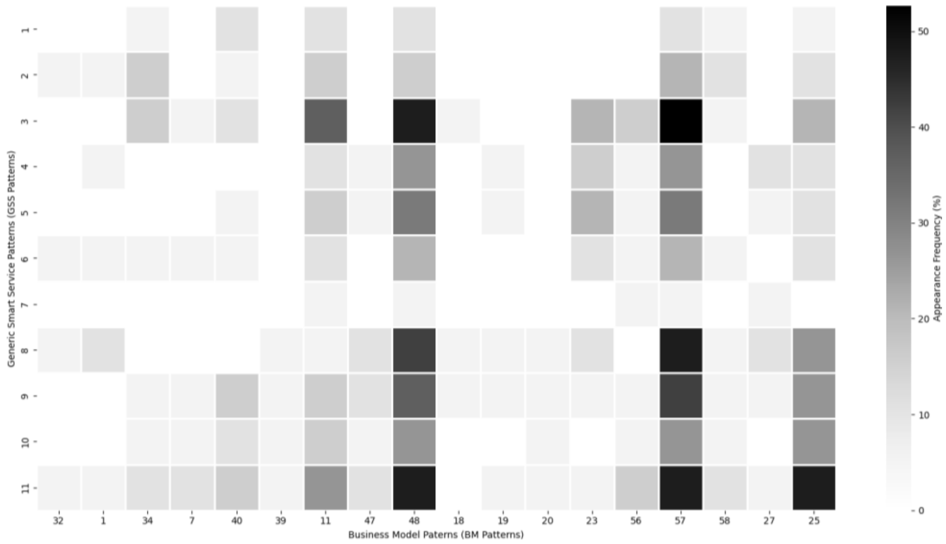

Fig. 3. Contingency table of BM vs. GSS patterns

7 Conclusion and outlook

This study aimed to investigate the relationship between the business model of smart services and their technical structure. By analyzing 19 case studies, we determined that strategic business decisions influence the IT architecture of smart services and to what extent. The results of this study provide a basis for further research in this area.

Additionally, the generic smart service patterns identified can be utilized by companies in the development and enhancement of new and existing smart services. The connections identified between BM patterns and GSS patterns enable the creation of a well-grounded blueprint of the IT architecture of smart services at an early stage, which can assist in making fundamental decisions. This can also aid in identifying and addressing challenges and risks at an early stage. For companies that already have established smart services, this research offers the opportunity to explore alternative business models that are employed with similar technical infrastructures.

Applying the GSS patterns and BM patterns to additional case studies and projects can enhance the patterns and uncover more GSS patterns. The current study serves as a foundation for further research on the influence of the business model on technical implementation. However, the study did not examine the influence of the individual elements of a business model, such as the value proposition or the revenue model. These dependencies could be further investigated. Additionally, it would be valuable to examine the influence of smart service use cases as proposed by Budde et al. [23], and an in-depth analysis of the structure of the cloud and its relationship to business model patterns also presents potential for future research.

References

[1] M. M. Herterich, F. Uebernickel, and W. Brenner, “The Impact of Cyber-physical Systems on Industrial Services in Manufacturing,” *Procedia CIRP*, vol. 30, pp. 323–328, 2015, doi: 10.1016/j.procir.2015.02.110.

[2] A. Alghisi and N. Saccani, “Internal and external alignment in the servitization journey – overcoming the challenges,” *Production Planning & Control*, vol. 26, 14-15, pp. 1219–1232, 2015, doi: 10.1080/09537287.2015.1033496.

[3] A. Borgmeier, A. Grohmann, and S. F. Gross, Eds., *Smart Services und Internet der Dinge: Geschäftsmodelle, Umsetzung und Best Practices: Industrie 4.0, Internet of things (IoT), Machine-to-Machine, Big Data, Augmented Reality Technologie*. München: Hanser, 2017.

[4] T. Baines and H. Lightfoot, Eds., *Made to serve: How manufacturers can compete through servitization and product-service systems*. Chichester, West Sussex, United Kingdom: Wiley, 2013

[5] M. Chalal, X. Boucher, and G. Marques, “Decision support system for servitization of industrial SMEs: a modelling and simulation approach,” *Journal of Decision Systems*, vol. 24, no. 4, pp. 355–382, 2015, doi: 10.1080/12460125.2015.1074836.

[6] A. Valtakoski, “Explaining servitization failure and deservitization: A knowledge-based perspective,” *Industrial Marketing Management*, vol. 60, pp. 138–150, 2017, doi: 10.1016/j.indmarman.2016.04.009.

[7] H. Gebauer, E. Fleisch, and T. Friedli, “Overcoming the Service Paradox in Manufacturing Companies,” *European Management Journal*, vol. 23, no. 1, pp. 14–26, 2005, doi: 10.1016/j.emj.2004.12.006.

[8] T. Mittag, M. Rabe, T. Gradert, A. Kühn, and R. Dumitrescu, “Building blocks for planning and implementation of smart services based on existing products,” *Procedia CIRP*, vol. 73, pp. 102–107, 2018, doi: 10.1016/j.procir.2018.04.010.

[9] S. Bonnemeier, F. Burianek, and R. Reichwald, “Revenue models for integrated customer solutions: Concept and organizational implementation,” (in En;en), *J Revenue Pricing Manag*, vol. 9, no. 3, pp. 228–238, 2010, doi: 10.1057/rpm.2010.7.

[10] E. Fleisch, M. Weinberger, and F. Wortmann, “Geschäftsmodelle im Internet der Dinge,” *HMD*, vol. 51, no. 6, pp. 812–826, 2014, doi: 10.1365/s40702-014-0083-3.

[11] H. Jodlbauer, *Digitale Transformation der Wertschöpfung*. Stuttgart, Germany: Verlag W. Kohlhammer, 2018.

[12] T. Bieger, D. zu Knyphausen-Aufseß, and C. Krys, Eds., *Innovative Geschäftsmodelle*. Berlin, Heidelberg: Springer Berlin Heidelberg, 2011.

[13] A. Osterwalder and Y. Pigneur, *Business Model Generation: Ein Handbuch für Visionäre, Spielveränderer und Herausforderer*. Frankfurt/New York: Campus Verlag, 2011.

[14] O. Gassmann, K. Frankenberger, and M. Choudury, *Geschäftsmodelle entwickeln: 55+ innovative Konzepte mit dem St. Galler Business Model Navigator,* 3rd ed. München: Hanser, 2021.

[15] M. Kohtamäki, V. Parida, P. Oghazi, H. Gebauer, and T. Baines, "Digital servitization business models in ecosystems: A theory of the firm," *Journal of Business Research*, vol. 104, pp. 380–392, 2019, doi: 10.1016/j.jbusres.2019.06.027.

[16] J. Pöppelbuß and C. Durst, "Smart Service Canvas – Ein Werkzeug zur strukturierten Beschreibung und Entwicklung von Smart-Service-Geschäftsmodellen," in *Dienstleistungen 4.0*: Springer Gabler, Wiesbaden, 2017, pp. 91–110.

[17] M. E. Porter and J. E. Heppelmann, "How smart, connected products are transforming competition," *Harvard business review*, vol. 92, no. 10, pp. 64–88, 2014.

[18] M. Ardolino, M. Rapaccini, N. Saccani, P. Gaiardelli, G. Crespi, and C. Ruggeri, "The role of digital technologies for the service transformation of industrial companies," *International Journal of Production Research*, vol. 56, no. 6, pp. 2116–2132, 2018, doi: 10.1080/00207543.2017.1324224.

[19] A. Holtschulte, *Praxisleitfaden IoT und Industrie 4.0: Methoden, Tools und Use Cases für Logistik und Produktion*. München: Hanser, 2021.

[20] *Internet of Things (IoT) – Reference architecture*, ISO/IEC 30141, International Organization for Standardization, 2018.

[21] J. W. Walewski, "Internet-of-Things Architecture IoT-A: Project Deliverable D1.2 – Initial Architectural Reference Model for IoT," 2011. Accessed: Jan. 17 2023.

[22] A. Bassi *et al.*, *Eds.*, *Enabling Things to Talk: Designing IoT solutions with the IoT Architectural Reference Model*, 1st ed. Berlin: Springer Berlin; Springer, 2016.

[23] L. Budde, R. Hänggi, T. Friedli, and A. Rüedy, *Smart Factory Navigator: Identifying and Implementing the Most Beneficial Use Cases for Your Company--44 Use Cases That Will Drive Your Operational Performance and Digital Service Business*. Cham: Springer International Publishing AG, 2023.

[24] C. Kowalkowski and W. Ulaga, *Service strategy in action: A practical guide for growing your B2B service and solution business*: Service Strategy Press, 2017.

[25] F. Wortmann, D. Bilgeri, M. Weinberger, and E. Fleisch, "Ertragsmodelle im Internet der Dinge," in *Betriebswirtschaftliche Aspekte von Industrie 4.0*: Springer Gabler, Wiesbaden, 2017, pp. 1–28.